WHAT´S A POLYURETHANE

Thermoplastic polyurethanes (TPUs) are lineal polymers formed by the polymerization reaction of three basic components:

1. A diisocyanate (NCO—R—NCO)
2. A short-chain diol , so-called chain extender (OH—R´—OH)
3. A long-chain diol (OH ——————————OH)

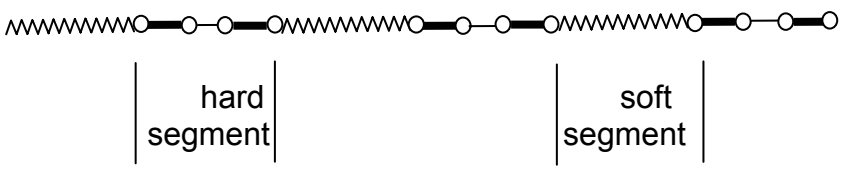
As the reaction of formation of the urethane group is:

R—NCO + R´—OH ⟶ R—NH—COO—R´

The structure of the lineal polymeric chain of thermoplastic polyurethane is in blocks, alternating two different types of segments linked together by covalent links, forming a block copolymer. These segments are:

1. HARD SEGMENTS
   These are segments formed by the reaction of the diisocyanate and the short-chain diol. They have a high density of urethane groups of high polarity, and for this reason, they are rigid at room temperature (high hardness).
2. SOFT SEGMENTS
   These are segments formed by the reaction of the diisocyanate and the long-chain diol. They have a low polarity as they have a very low density of urethane groups, and therefore, they are flexible at room temperature (very low hardness).

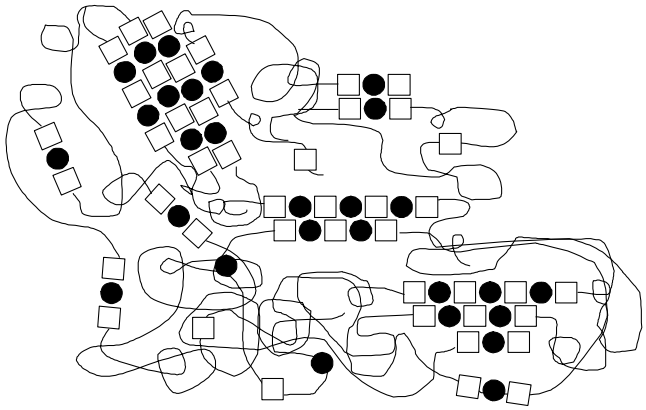
A general structure of thermoplastic polyurethane's chain would be the following:



∧∧∧∧∧∧∧∧	rest of long-chain diol
▬	rest of diisocyanate
—	rest of short-chain diol
o	urethane group

The polarity of hard segments produces a strong attraction between them, which causes a high degree of aggregation and order in this phase, forming crystalline or pseudo-crystalline areas located in a soft and flexible matrix. This so-called phase separation between both blocks will be more or less important, depending on the polarity and molecular weight of the flexible chain, the production conditions, etc. The crystalline or pseudo-crystalline areas act as a physical crosslink, which accounts for the high elasticity level of TPUs, whereas the flexible chains will impart the elongation characteristics to the polymer.

The schematic representation of the segmented micro structure of a polyurethane block copolymer would be the following:



(• chain extender ; □ isocyanate ; — polyol)

These “pseudo crosslinks”, however, disappear under the effect of heat, and thus the classical extrusion, injection molding and calendering processing methods are applicable to these materials. Consequently –and not less importantly- TPU scraps can be reprocessed. When TPUs are cold, the “pseudocrosslinks” reappear again, providing the elastic properties to the obtained article.

When TPUs are dissolved in a proper solvent, the “pseudo crosslinks” are also broken up by the solvent, and therefore, disappear. Due to this it is possible to apply a TPU in solution by classical methods of coating applications; when the solvent evaporates the “pseudo crosslinks” are formed again.

This peculiar structure which differentiates thermoplastic polyurethanes from other polymers provides polyurethanes with the following main properties:

- very high elasticity
- excellent abrasion resistance
- very good tear strength
- good oil and grease resistance

- excellent mechanical properties , combined with a rubber-like elasticity
- outstanding low-temperature performance
- high transparency

When stress is applied to a band of thermoplastic polyurethane, the presence of flexible and soft domains allow it to be stretched; while the rigid and hard domains store a great amount of the applied energy in such a way that, when the stress is released, it snaps back substantially to its original dimensions. This rubber-like elasticity is also responsible for the excellent abrasion and tear strength characteristics.

The soft domains provide the thermoplastic polyurethane with a very low T_G – in comparison with other polymers of the same hardness - maintaining the elasticity at very low temperatures.

For TPUs up to 98ş Shore A , the dimensions of crystalline areas are smaller than the wavelength of visual light , which makes these TPUs transparent – a unique property of TPUs within the family of TPEs.

The presence of polar and non polar counterbalanced microdomains in the TPUs' structure is the cause of the good chemical resistance of TPUs, particularly oil and grease resistance.

Thermoplastic polyurethanes are very versatile items, since a variety of soft and hard segments can be combined, with their respective ranges of molecular weights, and considering also the variety of molecular weights of the final polymer. So that it is possible to obtain from very soft (60ş Shore A) to very hard polyurethanes (80ş Shore D), with different degrees of crystallinity, to be used in many applications and market segments which require high performance.